



KING COUNTY

Odor Prevention Policy Recommendations

Regional Wastewater Services Plan Odor Control Strategy

March 18, 2003

**King County
Department of Natural Resources and Parks
Wastewater Treatment Division**

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Introduction

This document provides the recommended policy for the prevention of nuisance odors from King County's Wastewater Treatment Division's (WTD) facilities as required under the Regional Wastewater Services Plan (RWSP) and Ordinance number 13680, Section 5B TPP-4. This ordinance requires the following:

- Establishment of odor control goals at all treatment plants
- Design and operation of odor control facilities to meet the goals
- Investigation of potential technologies and costs
- Recommendation of a policy to the King County Council for inclusion in the RWSP
- Significant reduction of South Treatment Plant odors below 1993 air model levels

The information provided herein addresses the issues above. Policy recommendations, associated potential costs and background information are provided in this and in the associated document entitled *Wastewater Odor Prevention*. Odor prevention levels are defined herein with a discussion of odor causes, control methods, impact assessment and methods of measuring odor prevention program success. An assessment of odor prevention levels currently achieved by the wastewater facilities is provided with recommendations on the odor prevention level at which King County's facilities should operate to minimize community nuisance. Resources that will be required to achieve and maintain the recommended odor prevention levels are discussed and estimated.

The subjective interpretation of odors makes difficult the quantification of overall odor impacts. Odor perception is dependent on the intensity of the odor, its character, duration and the frequency of odor impacts. In addition, tolerance to odors varies from person to person. However, some generalities can be drawn regarding a community's overall tolerance. In regions of excellent air quality, such as Puget Sound, the tolerance for air pollution, including odors is quite low. The Puget Sound Clean Air Agency has the legal authority to regulate odor levels but the neighbors of King County's facilities will likely set the ultimate odor standards more stringently through direct contact with WTD facilities.

Because odor tolerance is community-dependent, odor prevention must be defined within the context of the community concerned. Using existing King County wastewater facilities and programs as a baseline, teams of WTD personnel and outside engineering experts held six workshops to assess the odor prevention levels achieved at the South and West Point treatment plants. Using these levels of odor prevention, higher and lower levels of odor prevention have been extrapolated and are defined in this document. WTD is working to minimize odor impacts and has determined the level of odor prevention necessary for each King County wastewater facility based on the existing and extrapolated odor prevention levels. Estimates of the resources necessary to achieve odor prevention success are provided.

King County receives about sixty wastewater related odor complaints each year which is actually low considering the fact that each day approximately 250 million gallons of raw sewage is passing through densely populated areas and is then treated at plants surrounded by business, residential and recreational areas. However, using the volume of complaints received only partially defines odor prevention program success. It is widely accepted that more people are affected by wastewater odors than file formal complaints. Therefore, odor prevention programs must be evaluated on more than just the number of odor complaints received. The policies recommended below will provide a holistic, robust and effective program of nuisance odor prevention.

Implementation of this policy will require authorization for substantial capital investment and operating costs. A three-phase implementation approach is recommended as outlined in Appendix A. Phase 1 would implement those projects listed as Imperative in Tables A.1 and A.3. The Phase 1 project cost estimates for required capital are approximately \$4,300,000 for the South Plant and \$810,000 for the West Point Treatment Plant over three years following authorization. The increase in annual operating costs would be about \$360,000 and \$220,000 for the South and West Point Treatment Plants respectively.

After completion of the Phase 1 projects, a one-year evaluation period would be used to study the effects of the improvements. If odors are proven to be sufficiently controlled no further work will be necessary. If further odor control is required, the improvements listed as Recommended in Appendix A would be implemented in Phase 2 followed by another year-long evaluation period. Finally, if still more improvements are required, those projects listed as Optional would be implemented in Phase 3. The additional efforts could raise the total required capital to approximately \$17,500,000 and annual operating costs to about \$890,000 for improvements to the South Plant over a nine-year period. Over this same period total capital for improvements at the West Point Treatment Plant could rise to approximately \$2,000,000 and operating costs to about \$540,000 dollars annually.

Policy Recommendations for Odor Prevention

The recommendations that follow are provided for the creation of a set of comprehensive policies for preventing odor nuisance events due to the activities and processes occurring in and around King County's wastewater conveyance and treatment systems. The recommendations are intended to result in a policy that will create a broad program of odor prevention that goes beyond conventional odor control. The proposed expansion of current efforts to prevent nuisance odors will significantly decrease the odor impacts on those communities near King County's wastewater facilities and bring the WTD to the forefront of wastewater utilities in its approach to dealing with odor issues.

Recommended Policies

King County Dept. of Natural Resource & Parks – WTD Odor Prevention Policy

King County's goal is to prevent and control nuisance odor occurrences at all treatment plants and associated conveyance facilities through the implementation of an odor prevention program that goes beyond traditional odor control. To achieve these goals, the following policies shall be implemented:

1. Existing facilities shall be retrofit in a phased manner up to the odor prevention level that reflects Best in the Country for existing facilities as defined in Table 1 of the Odor Prevention Policy Recommendations document dated March 18, 2003. Odor prevention systems will be employed as required to meet the goal of preventing and controlling nuisance odor occurrences.
2. The executive shall phase odor prevention systems implementing the tasks that generate the greatest improvements first, balancing benefit gained with cost, and report to the council on the status of the odor prevention program on an annual basis.
3. New regional treatment facilities shall be constructed with odor control systems that are designed to meet the odor prevention level that reflects the best in the country for new facilities of similar size.
4. Design standards will be developed and maintained for odor control systems to meet the county's odor prevention and control goals.
5. A comprehensive odor control and prevention monitoring program for the county's wastewater facilities will be developed. This program shall include the use of near facility neighbor surveys and tracking of odor complaints and responses to complaints and shall consider development of an odor prevention benchmarking and audit program with peer utilities.
6. New odor prevention and measurement technologies will be assessed and methods for pilot testing new technologies identified when determined by the executive to be necessary and appropriate for achieving the goals of this policy.

Odor Prevention Program

Preventing nuisance odor impacts is a major goal of responsible wastewater treatment organizations. In pursuit of this goal, a program of overall odor prevention, not just odor control, is necessary to address the proper design, operation and maintenance of wastewater facilities and their associated odor control systems. Many may consider the difference between an odor control and odor prevention program merely semantic in nature. However,

odor prevention represents a holistic program and a basic philosophical shift in the approach to solving the nuisance odor problem.

A comprehensive odor prevention program must address all the factors that contribute to nuisance odor impacts. Programs are frequently developed that focus solely on odor control devices and are limited to the collection and treatment of foul air emitted from wastewater systems. Controlling odor emissions in this way is not always sufficient to reduce odor impacts to levels that will satisfy the neighbors surrounding the wastewater facility. Even if all the odor-emitting sources are enclosed and their foul air is evacuated to an odor control device, odors can still escape. This can occur if there is a treatment process upset, a malfunction of the control device or if basic maintenance practices allow the creation and escape of untreated odorous gases.

Odor tolerance varies over time and affected communities tend to demand ever lower and less frequent odor impacts. In the time since the design and construction of most of King County's facilities, the standard of odor tolerance has changed, making necessary a current evaluation of odor prevention. The sections below describe various levels of odor prevention and the manner in which they were determined.

Various levels of odor prevention must be defined in terms that are understood by all involved. These definitions must take into account the sensitivity of the community and how odors are generated and ultimately impact the surrounding population. The level of odor prevention ultimately selected must be sufficient to satisfy the immediate communities while maximizing overall public benefit. Issues relevant to the selection of an acceptable odor prevention level are discussed below.

Defining Prevention Levels for King County

To establish levels of odor prevention that are accepted and understood by the community it is appropriate to use common and familiar points of reference. Table 1 below identifies the defining characteristics of each of four different levels of odor prevention.

Fortunately, King County has two major wastewater treatment facilities that employ various levels of odor prevention systems and can be used to establish reality-based odor prevention levels. The WTD has performed an evaluation of the two major treatment plants and associated odor control systems, maintenance practices, operating data, and previous third party evaluations to establish current odor prevention levels associated with each plant. As a result of significant system and topographic differences at the two treatment plants, and the density and proximity of neighbors, odor prevention currently achieved by each facility is at definable and different levels. This evaluation has provided a level of odor prevention for each plant from which other odor prevention levels have been extrapolated.

Table 1: Odor Prevention Level Characteristics

Defining Characteristic	Odor Prevention Level				
	High/New Plant ^a	High/Existing Plant Retrofit ^b		Medium	Low
Gases Captured from Odorous Processes Capable of Causing Nuisance Impacts	All	All		Most	Some
Best Management Practices Identified and Followed	Yes	Yes		Partial	No
Odor Dilutions to Threshold ^{c,d}	0-3 ^e	0-3 ^e	3-5 ^f	5-20 ^e	20-50 ^e
Frequency of Impact (Hours per Year) ^d	<50	<100	<100	<100	>100

- a) Best in the country for new facilities
- b) Best in the country for existing facilities
- c) Odor intensity above background sources due to wastewater facility emissions
- d) Maximum allowable design value
- e) Routine operating range
- f) Non-routine operating range

Odor Prevention Levels - Points of Reference

The West Point Treatment Plant and the South Treatment Plant in Renton are both secondary treatment facilities that utilize primary sedimentation, aeration basins, secondary sedimentation and anaerobic digestion to treat wastewater prior to discharge to Puget Sound. At the time of their design the potential for odor impacts was assessed using appropriate available methods. Several significant differences in the design and operation of the plants render them at two different levels of odor prevention capability by virtue of their current design configurations. The major differences between the plants are noted below.

Aeration basins provide secondary treatment by allowing aerobic biological activity to consume organic pollutants. The treatment plant at West Point uses high purity oxygen to oxygenate the wastewater in its covered aeration basins, while the South Treatment Plant uses compressed air in uncovered basins. This results in approximately 15 times the volume of gas passing through the South Treatment Plant's aeration basins compared to those at the West Point Treatment Plant. As a result, more odorous gases are passed out of the aeration basins at the South Treatment Plant than from those at the West Point Treatment Plant. The gases emitted from the aeration basins at both facilities are discharged directly to the atmosphere without treatment.

The second design parameter that is of significant difference between the two facilities is the chemistry in each facility's wet chemical scrubbers. In both systems, an oxidant may be added to chemically react with the odorous compounds so that they are not released to the air. The South Treatment Plant's scrubbers were designed to use sodium hypochlorite as the oxidant while the West Point Treatment Plant's systems were designed to use hydrogen peroxide. Hydrogen peroxide has proven over time to be less effective in preventing odorous gas emissions than sodium hypochlorite.

Significant improvements in odor prevention can be achieved at both the West Point and South treatment plants by improving their odor control systems and methods of operation. Implementation of the improvements that follow in Appendix A will allow the plants to operate with very low-level odor impacts on the surrounding communities. However, bringing the plants to the level of odor prevention achievable by a plant of contemporary design with state-of-the-art odor prevention systems integrated with the wastewater treatment processes is essentially impossible. Substantial portions of the facilities would require significant modifications and would require virtually rebuilding major portions of the treatment plants.

South Treatment Plant Odor Prevention

Historical Perspective

The South Treatment Plant is located between the cities of Tukwila and Renton approximately five miles south of the King County airport and is bordered by office parks, light industry and nearby residential neighbors. The location of the plant and the proximity of its neighbors can be seen on the King County WTD Facilities Map (Figure A) and a plant photo (Figure B). The plant originally began operations in July of 1965. In 1991 the Renton III project began to increase the plant's wastewater treatment capacity. As an integral part of the expansion, wet chemical odor control scrubbing systems were added to help control the anticipated additional odor impacts.

Current Odor Prevention Level

The South Treatment Plant's odor prevention level has been assessed at the Medium (Table 1) level. As described in the *Wastewater Odor Prevention* document, many odorous sources at the South Treatment Plant are covered and their associated foul air is treated prior to release. However, the odors from several sources remain untreated. This, coupled with odor complaint data and observations by process, operations and engineering personnel, has led to the consensus among participating WTD staff that the South Treatment Plant represents a Medium level of odor prevention ability.

Odor Prevention Level Recommendation

As with all King County facilities, it is recommended that the South Treatment Plant be configured to operate at an odor prevention level sufficient to prevent a nuisance. Implementation of certain capital, operational and maintenance changes can accomplish a High/Existing Plant Retrofit odor prevention level at the approximate costs and within the approximate time frames listed in Appendix A.

Requirements to Achieve Recommended Odor Prevention Level

In 1999 the Renton III Pre-Design – Odor Control Program report recommended several capital changes to prevent odor emissions. Those recommendations that have not yet been implemented included covering, evacuating and treating foul air from the following sources:

- Return Activated Sludge (RAS) Channel

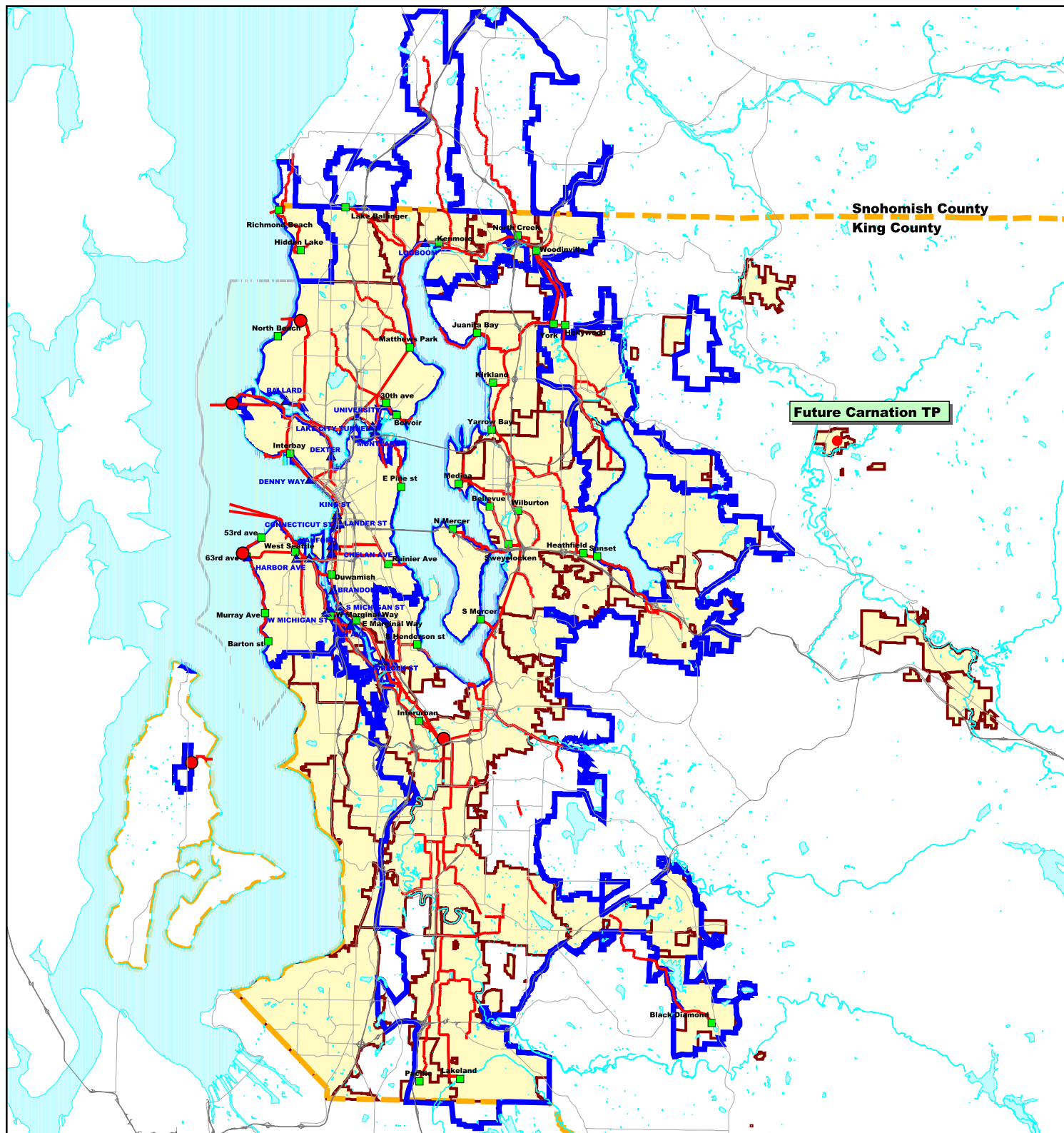


Figure A: King County WTD Facilities Map

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King County

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November 19, 2002

Legend

- Freeway
- KC Treatment Plants
- KC Regulator Stations
- KC Pump Stations
- KC Sewerlines
- KC WTD Service Area
- KC Boundary
- Cities

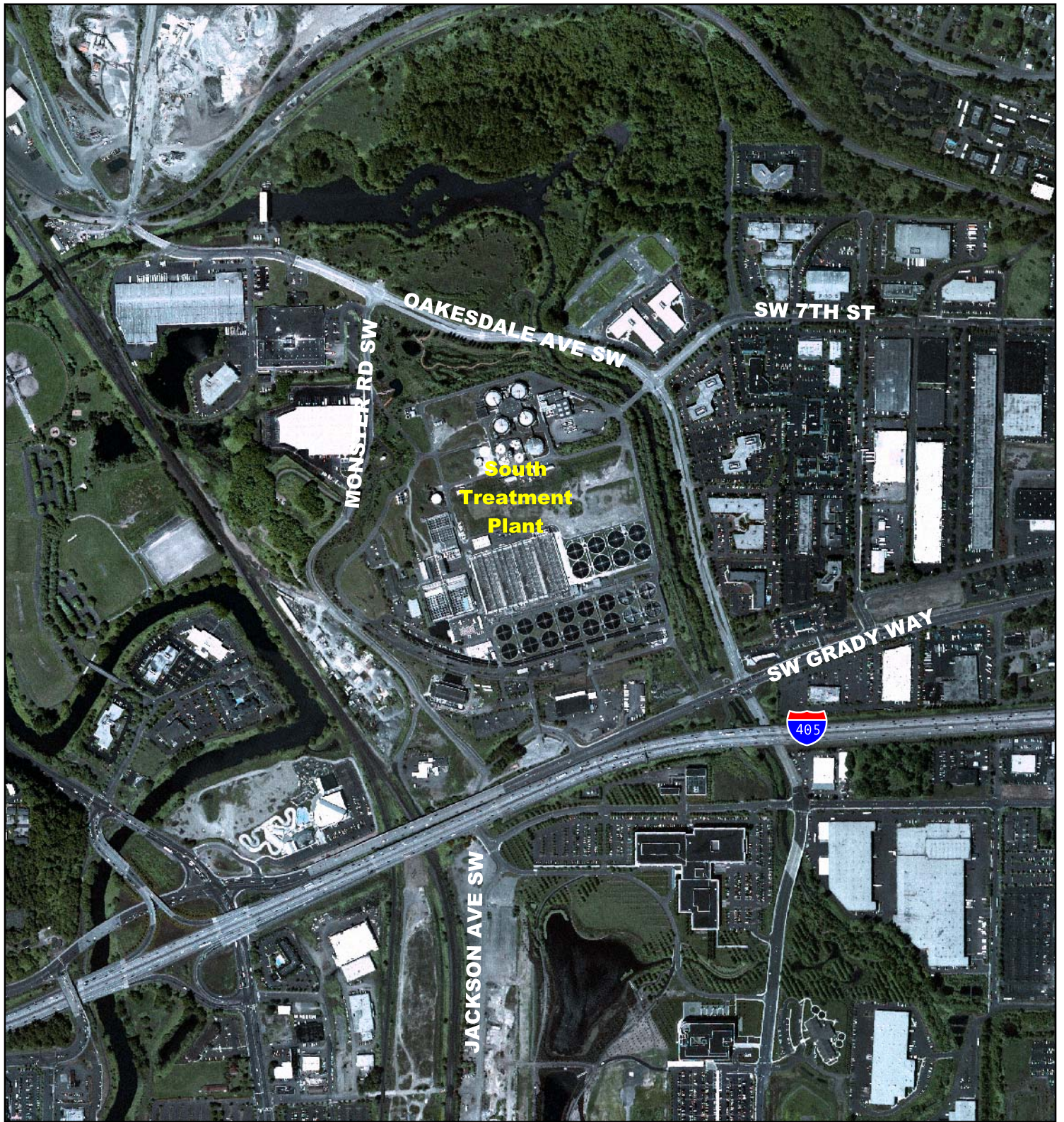


Figure B: South Treatment Plant

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September 18, 2002

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- Mixed Liquor Channels
- Aeration Tanks
- North & South Primary Sedimentation Tanks

It further recommended repair of the digester covers. Changes to the digester covers have since been implemented so that this action is no longer necessary. The 1999 report provided estimated capital costs to affect a variety of capital changes to enhance odor control. Those changes that have not yet been implemented are included in Table A.1 of Appendix A with additional improvements considered appropriate by WTD staff. These additional improvements, detailed in Appendix A, will require capital investments in equipment and increased expenditures for operation and maintenance. Capital improvements include capture and treatment of foul air from the grit structure and the purchase of additional odor monitoring equipment. Operational changes will increase the rate of consumable materials used to prevent odor production and remove odors from foul air streams. Maintenance of process and odor prevention equipment will be enhanced to reduce odor emissions and maintain odor removal efficiencies of the odor prevention equipment. Removing odor-causing debris from process equipment, monitoring of odorous emissions and additional attention to odor control equipment will increase the level of odor prevention achievable at the treatment plant.

The costs have been adjusted to 2002 dollars using an annual inflation factor of three percent. In addition to the capital costs, additional time will be required by plant personnel to perform O&M activities associated with the new odor prevention methods. The time identified with the additional odor prevention activities is also listed in Table A.1 of Appendix A as the number of full time equivalent (FTE) employees required. The approximate phasing of improvement implementation is shown in Table A.2.

West Point Treatment Plant Odor Prevention

Historical Perspective

The West Point Treatment Plant is located northwest of Discovery Park approximately four miles west of the Ballard bridge. The location of the plant and proximity of its nearby neighbors can be seen on the King County WTD Facilities Map (Figure A) and a plant photo (Figure C). The plant originally began operation in 1964 and was most recently upgraded in 1991 to add secondary treatment processes. As an integral part of the expansion, wet chemical odor control scrubbing systems were added to help control the anticipated additional odor generation.

In November 1998 the Odor Assessment and Preliminary Design report regarding the status of odor sources at the West Point Treatment Plant was produced. The report identified what were believed to be the plant's points of odorous emissions and recommended steps to reduce emissions from those sources.



Figure C: West Point Treatment Plant

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Current Odor Prevention Level

The West Point Treatment Plant treats the vast majority of its odorous air with liquid chemical scrubbers. This should allow the achievement of a High level of odor prevention. For these reasons, WTD staff defined the odor prevention level capability of the plant as High by virtue of its design. However, there are operational procedures and events at the West Point Treatment Plant that lowers the ability to prevent nuisance odors to the Medium level.

Odor Prevention Level Recommendation

As with all King County facilities, it is recommended that the West Point Treatment Plant be configured to operate at an odor prevention level sufficient to prevent a nuisance. This will require that the West Point Treatment Plant be raised from Medium to a maintainable High/Existing Plant Retrofit odor prevention level. Operating the facility at a High odor prevention level can be accomplished by implementing certain capital, operational and maintenance changes.

Requirements to Achieve Recommended Odor Prevention Level

In the 1998 Odor Assessment and Preliminary Design report, cost estimates to implement a variety of suggested improvements to enhance odor control were provided. The WTD has already implemented many of the changes to prevent odors from those sources that were either high odor emitters or required simple modifications. Those improvements and others that are considered appropriate by WTD, follow in Appendix A. The costs have been adjusted to 2002 dollars using an inflation factor of three percent. The tentative project schedules and costs of implementation by task are provided in Appendix A.

Improvement recommendations detailed in Appendix A include changes to odor prevention systems that will require capital investments in equipment and increased expenditures for operation and maintenance. Capital improvements include modification of the existing odor scrubber chemical systems, capture and treatment of foul air from the division and mixed liquor channels, and the purchase of additional odor monitoring equipment. Operational changes will increase the rate of consumable materials used to prevent odor production and remove odors from foul air streams. Maintenance of process and odor prevention equipment will be enhanced to reduce odor emissions and maintain odor removal efficiencies of the odor prevention equipment. Removing odor-causing debris from process equipment, monitoring of odorous emissions and additional attention to odor control equipment will increase the level of odor prevention achievable at the treatment plant.

Operation and maintenance of the odor control systems and odor prevention tasks will require increased labor by the treatment plant operators. The labor identified with the additional odor prevention activities is listed in Appendix A as the number of FTE employees required.

Vashon Island Treatment Plant Odor Prevention

Historical Perspective

The treatment plant on Vashon Island was built in 1972 and operated by the Vashon Island Sewer District until acquired by King County in 1999. The plant location is shown in Figure A. A photo of its proximity to neighbors is provided as Figure D. The plant is located in a low-density population area approximately one half-mile northeast of Vashon Island's main business center. The plant utilizes aerobic processes appropriate for the low wastewater volumes treated. These processes emit low level odorous gases that have not significantly impacted the surrounding community. To date, no odor control equipment has been installed in or around the facility. A general upgrade to the treatment plant is planned to be complete by 2006 and will include odor prevention systems and procedures.

Current Odor Prevention Level

The level of odor prevention the Vashon plant currently achieves has been assessed at a Medium level. This is achieved because the untreated low odor emissions from the plant's processes do not severely impact the relatively low-density neighborhood.

Odor Prevention Level Recommendation

As with all King County facilities, it is recommended that the Vashon Island Treatment Plant be configured to operate at an odor prevention level sufficient to prevent nuisance level odors. Development of the odor prevention systems will occur during the upcoming plant upgrade design. Capital improvements will be implemented as a result and operational and maintenance procedural changes will be developed as part of the design process.

Requirements to Achieve Recommended Odor Prevention Level

Improvement requirements will be determined during the plant upgrade design. Each facility is unique and odor prevention must be tailored to the specific system or facility. At a minimum, the treatment plant's headworks and solids handling processes will be ventilated to an odor prevention system. Criteria from Table 1 must be designed into the facility at the time of design to optimize the value of the odor prevention system investment.

Operation and maintenance of the odor control systems and odor prevention tasks will require the labor of the treatment plant operators. The time required by personnel to implement the odor prevention program will be assessed and appropriate staffing levels determined during the upcoming design. Proper funding of positions must be allocated to assure odor prevention program success.

Off-Site Conveyance System Odor Prevention

Historical Perspective

The wastewater conveyance system that exists today is in large part the result of the findings



Figure D: Vashon Island Treatment Plant

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February 5, 2003

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and recommendations set forth in the *Metropolitan Seattle Sewerage and Drainage Survey 1956-1958*. That document described the issues and design requirements for wastewater conveyance and treatment, but is silent on the issue of odors from wastewater sources.

Since its inception, the conveyance system has grown to include approximately 300 miles of pipe. The system passes through urban, rural, residential and industrial neighborhoods. Increasing wastewater flows and population densities have resulted in increased odor impacts near certain conveyance facilities requiring the installation of odor control systems. Although the RWSP ordinance did not require a policy on the conveyance system, this recommendation includes extending the odor policy to the entire system. Current WTD design standards require odor control systems at all new or upgraded facilities.

In 1995 the WTD commissioned the *H₂S (hydrogen sulfide) Odor/Corrosion Control – Technical Work Plan & Budgetary Estimate* report. That report summarized the available data, potential technologies for odor control, and provided a work plan to address odor (and corrosion) problems in portions of the conveyance system. Based on this report, additional data and experience, the WTD will be completing by the second quarter of 2003 a comprehensive plan for odor and corrosion abatement in the conveyance system. This plan will address present and potential nuisance odor problems due to conveyance system operations.

Predicting odor emissions from the conveyance system is not a simple task. Approximately 10,000 connections from local public agencies (LPAs) contribute wastewater to the King County conveyance system that varies in flow rate and composition. The comprehensive plan will address odor prevention in those portions of the system that are known to, or are expected to, emit nuisance odors. As part of this effort, conveyance system hydrogen sulfide gas levels and other relevant parameters are being monitored and data is being collected to identify those areas requiring odor prevention measures.

Some odor emissions are not predictable and can result from high sulfide discharges from a LPA or may be the result of unplanned or inappropriate discharges by residential or industrial sources. This type of odor event can occur throughout the system but is usually localized around one of the 135-off-site facilities or approximately 3,000 manholes. Short-term transient odor problems can be corrected with temporary control measures such as sealing or installing small carbon inserts into manholes or other vent points. To deal with temporary large-scale odor events, the WTD has acquired five mobile odor control units. These units are carbon odor scrubbers housed in trailers that may be dispatched with mobile electrical generators to establish temporary odor control when the need arises.

The WTD currently requires that odor prevention be incorporated into each new offsite facility upgrade or new facility design. Multiple odor prevention projects are currently in design or construction.

Current Odor Prevention Level

For the most part the current conveyance system operates without generating nuisance odors. Off-site conveyance system operators and maintenance personnel monitor odor control systems as part of their routine inspections. As a result of this vigilance and maintenance, nuisance odors are generally prevented. These factors, coupled with odor complaint data and observations by the Division's process, operations and engineering personnel, led to ranking the conveyance system at a High/Existing Plant Retrofit level of odor prevention overall. However, as noted above, the system is quite dynamic and as flows and populations increase, problems with nuisance odors do occur. Below are discussions on odor complaint response and investigation and community relations that explain the approach to resolving these types of occurrences.

Odor Prevention Level Recommendations

As with all King County facilities, it is recommended that the conveyance system network odor prevention level remain at the High/Existing Plant Retrofit level described in Table I. As existing facilities are upgraded or new facilities are built, odor prevention is to be addressed and odor control systems installed that are appropriate for the site. Operations and maintenance activities will be evaluated in the design assessment so that odor prevention is designed into the facility to prevent future nuisance odors.

Requirements to Achieve Recommended Odor Prevention Levels

Each offsite facility is unique and odor prevention must be tailored to the specific requirements of each location in the conveyance system. To achieve a High/Existing Plant Retrofit level of odor prevention, the criteria from Table 1 must be designed into each facility that has the potential for impacting the community with nuisance odors.

Brightwater Treatment Plant Odor Prevention

Historical Perspective

A major component of the RWSP involves the siting, design, and construction of a new regional wastewater treatment system, called Brightwater. The Brightwater treatment system is being built to ensure that our region has sufficient wastewater treatment capacity and will serve the northern portion of King County's wastewater service area. Work is currently underway to site the Brightwater facilities, which includes a treatment plant, its associated conveyance pipelines, and a marine outfall. The Brightwater treatment system is scheduled to be commissioned and operating by 2010.

Odor Prevention Level Recommendations

King County has committed that the new plant will not be a nuisance to its neighbors. The design of the Brightwater facility provides the opportunity to design and implement a program that will represent a level of odor prevention that will be the "best in the country", or "High/New Plant" as described in Table I. Using state-of-the-art odor generation, emission and dispersion prediction tools, appropriate odor control technologies will be selected and

operational procedures developed to prevent odors from becoming a nuisance to the treatment plant and new conveyance system facility neighbors.

Requirements to Achieve Recommended Odor Prevention Level

As important as the selection of the wastewater treatment process is, so is the selection and development of an odor prevention strategy. Because the detailed design of the Brightwater plant has yet to begin, the details of the odor prevention methods have not been developed. The design and construction of these facilities from the ground up will allow the integration of odor prevention philosophies and measures that are impossible to implement at existing facilities.

To achieve a level of odor prevention that will be considered the “best in the country” (High/New Plant), the following criteria from Table 1 must be met:

- All odorous sources must be contained and foul air evacuated to scrubbers
- Scrubbers will be tuned to treat specific classes of gases at each scrubber stage
- Best management practices must be developed as an integral part of design
- Facilities will be designed not to exceed zero to three dilutions-to-threshold above background odors more than 50 hours per year

Accomplishing these objectives will require that the odor prevention program be developed concurrently with the overall treatment plant design. It must be fully developed so that the odor prevention systems are fully functional before wastewater is allowed to enter the treatment plant. This is already the practice of WTD.

Odor control equipment with redundant systems will be required as part of the overall odor prevention program to achieve the High/New Plant prevention level. Cost estimates will be developed during the design of the new facilities. Operation and maintenance of the odor control systems and odor prevention tasks will require the labor of the treatment plant operators. The time required of personnel to implement the odor prevention program will be assessed and appropriate staffing levels determined. Proper funding of positions must be allocated to assure odor prevention program success.

Odor Prevention Program Success Measurement

The level of nuisance odor impact on a community is only partially represented by the volume of formal odor complaints received. Many more people detect and are annoyed by odors than make the effort to file a complaint. The measurement of odor prevention success must, therefore, use not only odor complaint data but also other measurements to assess adherence to, and the effectiveness of, the program. An odor prevention program must consider not only the generation and final impact of odorous gases on the surrounding community, but also system and facility design, benchmarking against peer utilities, operation and maintenance practices, odor complaint response and investigation, and community relations. Each of these areas must be addressed and methods must be developed to measure and report the consistency of program compliance and effectiveness.

Peer Utility Benchmarking

It is recommended that King County institute an effort to join with peer utilities and establish benchmarks for odor prevention. Table 2 below compares standards established for wastewater facilities around the country. The plants listed in the table are in locations where topography and meteorology are substantially different from King County's. It would be prudent to establish benchmarks with utilities situated in similar coastal regions that share similar meteorology and topography that influence the dispersion and impact of odors. For instance utilities in Tacoma, Washington; Portland, Oregon; San Francisco, California; and Vancouver, British Columbia could be included. WTD staff are in the process of contacting utilities in these areas to assess the desire to participate in a benchmarking effort and mutual evaluation of peer odor prevention programs.

Wastewater Facility Design

The generation and release of odorous gases from wastewater treatment and conveyance facilities is very dependent on their design. Furthermore, as described in *Wastewater Odor Prevention* document, there are benefits and limitations to the various methods of measurement and odor control technologies. Therefore, it is imperative that each system be evaluated and designed on its own merits. During the design of a facility, the potential for odorous gas generation and release must be evaluated, dispersion of the odors must be estimated based on-site specific meteorology and topography and odor impacts assessed based on the proximity and density of the current and potential future populations. Odor control equipment must be selected and sized appropriately as part of this effort.

The WTD's Odor and Corrosion Control Taskforce is responsible for evaluating designs that may influence odor release. The Taskforce has developed a design standard for odor control systems that is used to lead designers to develop systems that are adequate to prevent nuisance odor impacts. Measurement of compliance with the design standard and the requirement of obtaining Taskforce approval of design will be tracked and evaluated as a measurement of odor prevention program success.

Operation & Maintenance Practices

Operation and maintenance of wastewater processes, equipment and facilities can have significant impacts on the generation and release of odors to the community. Standard operating procedures (SOP) are in use by the WTD but must be reviewed and modified periodically to include activities that will prevent nuisance odors. Review and modification of the current SOP and maintenance practices began during the second quarter of 2002 and will be subjected to periodic reassessment as part of a continuous improvement cycle. Odor abatement plans for potentially odorous operations and maintenance activities will be prepared and followed as part of the SOPs. Periodic review and assessment of how well the SOPs address odor prevention and how well they are implemented will become an odor prevention program measurement of success.

Table 2: Odor Standards at King County & Peer Utility Treatment Plants ^a

Plant	Surrounding Land Use	Threshold	Acceptable Number of Hours per Year that Can Exceed Threshold
East Bay Municipal Utility District (EBMUD), Oakland, CA	Industrial turning into residential	50 D/T (Phase 1 of odor control) 20 D/T (Phase 2 of odor control)	< 10 hours / year < 100 hours / year
Central Contra Costa County Sanitary District	Industrial with some residential and highway	4 D/T	< 100 hours / year
Sacramento County Regional Sanitation District, CA	Rural with growing residential	20 D/T	< 100 hours / year
Orange County Sanitation District, CA	Residential with highway	20 D/T	< 100 hours / year
Allegheny County Sanitation District, PA	Residential with highway	4 D/T	< 50 hours / year
City of Philadelphia, PA	Residential	20 D/T	< 100 hours / year
City of Calgary, Canada	Rural with growing residential	20 D/T	< 100 hours / year
Yountville, CA	Golf Course	4 D/T	< 100 hours / year

a) Source: *Preliminary Baseline Odor Assessment – King County South Treatment, April 8, 2002.*

Odor Complaint Response & Investigation

Being a good neighbor by preventing odors is part of the normal operation of WTD's conveyance system and treatment facilities. While there is a possibility for odors to occur, the WTD makes every effort to respond to odor complaints in a prompt and effective manner. King County considers an odor complaint a serious event and has listed odor complaint telephone hotline phone numbers in area phone books under King County Department of Natural Resources and Parks - WTD.

Personnel are available to respond to odor issues 24 hours a day. The odor hotlines connect directly to treatment plant main control offices where complaints are logged and the event is documented. Personnel are dispatched to the location identified by the complainant to investigate within two hours of receiving the complaint. The goals of the investigation are to identify the odor source, repair odor control equipment if necessary and maintain a neighborly relationship with the community. If the originator of the complaint desires, they are notified of the investigation findings.

Each month the Odor Control Taskforce reviews all odor complaints received to determine whether the actions taken in response were appropriate and to initiate further action if required. Prompt disposition and resolution of odor complaints that are the result of the WTD's activities are tracked and will be evaluated as a measure of success of the odor prevention program.

Community Relations

The WTD is actively informing and educating the public about the services it provides while protecting public health and the environment. Staff members inform the community about the processes used in the field of wastewater treatment including odor prevention and control methods used at our facilities.

Community relations staff act as liaisons between the citizens in our region and the WTD, providing assistance to residents, organizations and businesses with complaints, issues or concerns regarding projects, conveyance lines, facilities and other wastewater related issues. Open houses and educational tour programs are conducted to provide citizens the opportunity to learn about the treatment facilities in their neighborhoods. Brochures and other public education documents are available on the Internet to provide additional public information regarding wastewater odor prevention. Planning is currently underway for King County WTD's odor prevention-specific web page.

The annual Department of Natural Resources and Parks Water Quality and Near-Facility-Nearby Surveys are conducted to assess public sentiments about King County's wastewater treatment facilities and nuisance odor impacts. These surveys are a result of WTD's productivity initiative and are being used to establish a baseline of community sentiment. These surveys will continue to be used to assess the effectiveness of the Community Relations Unit, to determine whether additional work is required, and as an odor prevention program measurement of success.

Technology Assessment

WTD personnel are actively involved in the assessment of new odor prevention and measurement technologies. Members of the Odor and Corrosion Control Taskforce are actively involved in professional organizations such as the Water Environment Federation and remain abreast of developments in the field. If a new technology appears promising, laboratory or pilot tests are conducted to validate the equipment if operating data from field use is not available. Only after positive results are verified will a new technology be introduced as an option for odor prevention.

Measurement of success with this part of the odor prevention program will be to track and maintain data on emerging technologies and the results of technology testing.

Program Implementation

The WTD continues to develop and enhance its efforts to eliminate nuisance odors from its facilities. Work under the RWSP will move the Division to the forefront of odor prevention in the wastewater industry. In meeting the requirements of the RWSP ordinance, WTD has explained and outlined in this document a policy for odor prevention based on defined prevention levels for each of the major conveyance and treatment systems and the methods that will be used to measure the success of the program. Implementation of the program will require resources including capital expenditures and ongoing operation and maintenance costs. Additional personnel will be required to monitor and maintain the new and enhanced odor prevention systems and activities associated with the program.

Upon approval of the odor prevention policy, the WTD will develop a detailed action plan with specific milestones for the implementation of the of the odor prevention program. Those capital improvements described earlier in this document that are not yet under development will be scheduled for implementation. Implementation will be phased to generate the greatest improvements first, balancing benefit gained with cost. A schedule for the improvements has been included in Appendix A and was developed based on balancing the reduction of odor impacts against the potential cost. Odor prevention systems for the Vashon Island treatment plant, Brightwater facility and the associated conveyance systems will be developed concurrently with the design of those facilities.

Conclusions

Odor prevention is a major goal of responsible wastewater utilities and their governing bodies. As reflected in the odor prevention requirements in the RWSP ordinance and Operational Master Plan, King County and the WTD have shown that they are no exception to this rule.

The WTD has addressed the RWSP requirements in this document. The recommended Odor Prevention Policies set broad goals that provide the foundation for a holistic, robust and effective odor prevention program. Such a program will expand the current methods of odor control and place King County's WTD at the forefront of the wastewater industry with regard to odor prevention. The recommended policy specifically states that new regional treatment facilities will be designed to a standard that will represent the best odor prevention systems in the country, and that existing facilities will be configured to provide the best odor prevention possible given the constraints of their existing systems.

The goals for odor prevention at new and existing treatment facilities and for the conveyance system have been stated in this document. Development of the odor prevention goals has included recommendations for modifications to existing systems. Implementation of these modifications will result in the fulfillment of the RWSP requirement to significantly reduce odors from the South Treatment Plant and will decrease impacts from the West Point Treatment Plant as well. Endorsement of the proposed odor prevention policies will provide direction to the WTD to move forward with the odor prevention goals stated in this document.

APPENDIX A: Odor Prevention Improvements – Planning Level Cost Estimates & Implementation Timelines

Table A.1: South Plant Odor Prevention Improvements & Planning Level Cost Estimates												
Action	Benefits	Recommendations	Implementation Period	FTE Increase	Odor Impacts Avoided ^b	Cost of Odor Impacts Avoided Annually ^a	Odor Reduction Potential and Probable Costs ^c					
							High		Medium		Low	
							Capital	Annual O&M	Capital	Annual O&M	Capital	Annual O&M
Carbon change in Mobile odor Control units	Reduction in odor impacts due to unplanned carbon saturation and downtime for replacement.	Imperative. Low annual cost of impact avoidance. No FTE required. Implementation can begin immediately.	3 months		4032	\$4	\$0	\$15,000				
Purchase additional Jerome monitors.	Rapid troubleshooting of odor problems & data collection of hydrogen sulfide concentrations near the human odor detection level.	Imperative. Low capital & annual cost of impact avoidance. No FTE increase required. Implementation can begin immediately.	3 months		1440	\$4	\$50,000	\$2,000				
Increase Bioxide (Calcium/Sodium Nitrate) chemical dosing.	Reduces hydrogen sulfide (rotten egg) odors. Reduces consumption of consumables in foul air scrubbers and corrosion of infrastructure associated with hydrogen sulfide.	Imperative. No capital & low annual cost of impact avoidance. No FTE increase. Implementation can begin immediately.	2 months		4032	\$6	\$0	\$24,000				
Washing of treatment process tanks during draining activity.	Reduces odor emissions during tank cleaning. Odor reduction will be significant but intermittent because tank cleaning activity is not a constant process.	Imperative. No capital & low annual cost of impact avoidance. FTE increase required. Implementation can begin immediately.	3 months	0.5	4680	\$10	\$0	\$45,000				
Temporary covering/tenting of process tanks during maintenance.	Reduces odor emissions during tank cleaning. Odor reduction will be significant but intermittent due to the fact that tank cleaning activity is not a constant process.	Imperative. Low capital & annual cost of impact avoidance. No FTE increase required. Implementation can begin immediately.	12 months		1548	\$14	\$88,500	\$15,000				
Cover major odor emitting areas of the return activated sludge (RAS) channel. Evacuate & treat foul air.	Reduce strong musty offsite odor impacts frequently noticeable on I-405 by eliminating escape of untreated foul air.	Imperative. Significant lowering of impacts. Low annual cost of impact avoidance with moderate capital investment. No FTE increase required. Design can begin in 2003 if funding available.	36 months		2035	\$22	\$200,000	\$29,000				
Optimize wet scrubber chemical injection rates.	Maintain maximum foul air scrubbing efficiency	Imperative. Low annual cost of impact avoidance. Implementation can begin immediately.	3 months		2920	\$28	\$0	\$80,500				
Grit Structure Modifications.	Reduce sour offsite odor impacts frequently noticeable on I-405 by eliminating escape of untreated foul air.	Imperative. High capital but low annual cost of impact avoidance. Design can begin in 2003 if funding available.	36 months		1872	\$33	\$640,000	\$11,000				
Pre-Chlorination rate increase.	Reduce strong musty offsite odor impacts frequently noticeable on I-405 by chemically oxidizing odorous compounds in wastewater.	Imperative. Low annual cost of impact avoidance. Cost estimate based on gaseous chlorine use. Cost increase if sodium hypochlorite used. Implementation can begin immediately.	3 months		720	\$83			\$0	\$60,000		
Ventilation /Foul Air Scrubber system inspections.	Reduced odor emissions and shorter odor emission events by early detection of problems.	Recommended. Moderate annual cost of impact avoidance. FTE Increase required. Implementation can begin immediately.	6 months	0.7	576	\$109			\$0	\$63,000		
Cover first pass of aeration basins. Evacuate & treat foul air.	Reduce by approximately 80% the odor emissions from the aeration basins that produce strong musty offsite odor impacts frequently noticeable on I-405 by eliminating escape of untreated foul air.	Imperative. Significant lowering of impacts. Low annual cost of impact avoidance but high capital investment. No FTE increase required. Design can begin in 2003 if funding available.	36 months		2640	\$132	\$3,300,000	\$82,500				
Purchase OdaLog hydrogen sulfide monitors	Enhanced ability of WTD to monitor and identify locations of high hydrogen sulfide concentrations and associated risk of odor emissions and corrosion.	Recommended. Low capital & moderate annual cost. Low cost of impact avoidance. No FTE increase. Implementation can begin immediately.	3 months		50	\$148					\$32,000	\$0
Wastewater liquid phase sulfide monitoring for chemical injection adjustment.	Maximize odor reduction while minimizing chemical injection rates and costs	Optional. Moderate annual cost of impact avoidance. FTE increase required. Implementation can begin immediately.	6 months	0.5	288	\$156			\$0	\$45,000		
Cover remaining areas of return activated sludge (RAS) channel. Evacuate & treat foul air.	Reduce strong musty offsite odor impacts frequently noticeable on I-405 by eliminating escape of untreated foul air.	Optional. Consider for implementation only after first phase and of RAS channel covering complete and assessed.	24 months		278	\$162			\$200,000	\$29,000		
Increase frequency of fence line odor monitoring.	Provides a check of odor impacts from wastewater processes and foul air scrubbers. Although the reduction in foul air emissions would be slight, the cost is correspondingly low and will result in a reasonable benefit for the investment.	Optional. Moderate cost of avoiding only a few odor impacts. FTE increase required. Implement can begin immediately.	1 month	0.3	50	\$540					\$0	\$27,000
Cover mixed liquor channels. Evacuate & treat foul air.	Reduce strong musty offsite odor impacts frequently noticeable on I-405 by eliminating escape of untreated foul air.	Optional. Low reduction of impacts at high cost of impact avoidance. High capital cost. No FTE required. Begin design in 2003 if funding available.	36 months		48	\$2,358					\$1,000,000	\$33,000
Cover second, third & fourth passes of aeration basins. Evacuate & treat foul air.	Reduce by approximately 20% the odor emissions from the aeration basins that produce strong musty offsite odor impacts frequently noticeable on I-405 by eliminating escape of untreated foul air.	Optional. Cover only after first pass is covered if the second, third and fourth passes prove to cause offsite odor impacts. Begin design in 2008.	24 months		270	\$2,916					\$6,700,000	\$250,000
Cover primary sedimentation tanks. Evacuate & treat foul air.	Reduce musty offsite odor impacts sometimes noticeable on I-405 by eliminating escape of untreated foul air.	Optional. High capital and annual cost of impact avoidance. Design can begin in 2003 if funding available.	36 months		60	\$8,459					\$5,300,000	\$82,500
			Totals	2			\$4,278,500	\$304,000	\$200,000	\$197,000	\$13,032,000	\$392,500

a) Annualized cost of capital at 5% and O&M.
b) Index developed to assess impact on odor avoidance by implementation of individual improvement. Impact defined as at 5 dilutions-to-threshold for at least 5 minutes.
c) Odor Reduction Definitions: High > 1000 Impacts, 100 Impacts < Medium≤ 1000 Impacts, Low ≤ 100 Impacts

Table A.2: South Plant Odor Prevention Improvement Recommendations - Timelines & Costs by Task																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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Table A.3: West Point Treatment Plant Odor Prevention Improvements & Planning Level Cost Estimates												
Action	Benefits	Recommendations	Implementation Period	FTE Increase	Odor Impacts Avoided ^b	Cost of Odor Impacts Avoided Annually ^a	Odor Reduction Potential and Probable Costs ^c					
							High		Medium		Low	
							Capital	Annual O&M	Capital	Annual O&M	Capital	Annual O&M
Division channel ventilation improvements.	Stops escape of fugitive odors and corrosion of concrete structure. Rapid corrosion will lead to safety problems and will necessitate expensive corrosion damage rehabilitation	Imperative. Low capital cost of impact avoidance. No FTE increase. Begin design 2003.	24 months		2400	\$2	\$45,000	\$0				
Carbon change in Mobile odor Control units	Reduction in odor impacts due to unplanned carbon saturation and downtime for replacement.	Imperative. Low annual cost of impact avoidance. No FTE required. Implementation can begin immediately.	3 months		4032	\$4	\$0	\$15,000				
Purchase additional Jerome monitors.	Rapid troubleshooting of odor problems & data collection of hydrogen sulfide concentrations near the human odor detection level.	Imperative. Low capital & annual cost of impact avoidance. No FTE increase required. Implementation can begin immediately.	3 months		1440	\$5	\$60,000	\$2,000				
Increase Bioxide (Calcium/Sodium Nitrate) chemical dosing.	Reduces hydrogen sulfide (rotten egg) odors. Reduces consumption of consumables in foul air scrubbers and corrosion of infrastructure associated with hydrogen sulfide.	Imperative. No capital & low annual cost of impact avoidance. No FTE increase. Implementation can begin immediately.	2 months		4032	\$10	\$0	\$40,700				
Washing of treatment process tanks during draining activity.	Reduces odor emissions during tank cleaning. Odor reduction will be significant but intermittent because tank cleaning activity is not a constant process.	Imperative. No capital & low annual cost of impact avoidance. FTE increase required. Implementation can begin immediately.	3 months	0.4	1560	\$23	\$0	\$36,000				
Optimize wet scrubber chemical injection rates.	Maintain maximum foul air scrubbing efficiency	Imperative. No capital & low annual cost of impact avoidance. No FTE increase. Implementation can begin immediately.	3 months		2920	\$28	\$0	\$80,500				
Modify wet chemical scrubbers allowing two independent liquid sump chemistries for the primary treatment and solids handling scrubber systems.	Maximizes performance of foul air scrubbers by allowing adjustment of liquid chemistry appropriate to the foul air stream.	Imperative. Significant capital but low annual cost of impact avoidance. No FTE increase. Begin design 2003.	36 months		3000	\$36	\$705,000	\$50,000				
Increase frequency of fence line odor monitoring.	Provides a check of odor impacts from wastewater processes and foul air scrubbers. Although the reduction in foul air emissions would be slight, the cost is correspondingly low and will result in a reasonable benefit for the investment.	Recommended. Low annual cost of avoiding odor impacts. FTE increase required. Implement can begin immediately.	1 month	0.3	600	\$45			\$0	\$27,000		
Secondary sedimentation tank mixed liquor line draining.	Reduce odors emitted during refilling of tank.	Recommended. Low annual cost of avoiding only a few odor impacts. FTE increase not required. Implement can begin immediately.	12 months		90	\$45					\$50,000	\$0
Temporary covering/tenting of process tanks during maintenance.	Reduces odor emissions during tank cleaning. Odor reduction will be significant but intermittent due to the fact that tank cleaning activity is not a constant process.	Recommended. Low capital & annual cost of impact avoidance. No FTE increase required. Implementation can begin immediately.	12 months		468	\$47			\$88,500	\$15,000		
Ventilation /Foul Air Scrubber system inspections.	Reduced odor emissions and shorter odor emission events by early detection of problems.	Optional. Moderate annual cost of impact avoidance. FTE Increase required. Implementation can begin immediately.	6 months	0.7	576	\$109			\$0	\$63,000		
Purchase OdaLog hydrogen sulfide monitors	Enhanced ability of WTD to monitor and identify locations of high hydrogen sulfide concentrations and associated risk of odor emissions and corrosion.	Recommended. Low capital & moderate annual cost of impact avoidance. No FTE increase. Implementation can begin immediately.	3 months		50	\$148					\$32,000	\$0
Pre-Chlorination rate increase.	Reduce strong musty offsite odor impacts.	Recommended. Low annual cost of impact avoidance. Cost estimate based on gaseous chlorine use. Cost increase if sodium hypochlorite used. Implementation can begin immediately.	3 months		720	\$153			\$0	\$110,000		
Wastewater liquid phase sulfide monitoring for chemical injection adjustment.	Maximize odor reduction while minimizing chemical injection rates and costs	Recommended. Moderate annual cost of impact avoidance. FTE increase required. Implementation can begin immediately.	6 months	0.5	288	\$156			\$0	\$45,000		
Cover mixed liquor channels. Evacuate & treat foul air.	Reduce strong musty offsite odor impacts by eliminating escape of untreated foul air.	Optional. Low reduction of impacts at high cost of impact avoidance. High capital cost. No FTE required. Design could begin in 2003 if funding available.	36 months		48	\$2,358					\$1,000,000	\$33,000
Clean packed tower odor scrubber mist eliminator pads monthly instead of annually.	Increases air volume treated by reducing resistance to airflow. Reduces fugitive emissions from ventilated processes due to restricted airflow. Reduces odor emissions from fouled mist eliminator pads themselves.	Optional. Low reduction of impacts at high cost of impact avoidance. High capital cost. FTE increase required. Design could begin in 2003 if funding available.	3 months	0.2	5	\$3,600					\$0	\$18,000
Totals				2.1		\$6,768	\$810,000	\$224,200	\$88,500	\$260,000	\$1,082,000	\$51,000

a) Annualized cost of capital at 5% and O&M.
b) Index developed to assess impact on odor avoidance by implementation of individual improvement. Impact defined as at 5 dilutions-to-threshold for at least 5 minutes.
c) Odor Reduction Definitions: High > 1000 Impacts, 100 Impacts < Medium ≤1000 Impacts, Low ≤ 100 Impacts

Table A.4: West Point Treatment Plant Odor Prevention Improvement Recommendations - Timelines & Costs by Task

ID	Task Name	Fixed Cost	Cost1	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7				Year 8				Year 9				Year 10																			
				Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4																			
1	Division Channel Ventilation Improvements	\$45,000.00	\$0.00																																																								
2	Scoping, Budget, RFP	\$5,000.00	\$0.00	\$5,00																																																							
3	Consultant Selection	\$5,000.00	\$0.00					\$5,00																																																			
4	Design	\$10,000.00	\$0.00									\$10,000.00																																															
5	Const. Contract Procurement	\$5,000.00	\$0.00													\$5,00																																											
6	Construction	\$20,000.00	\$0.00																	\$20,000.00																																							
7	Carbon Changes in Mobile Odor Control Units	\$0.00	\$15,000.00	\$15,000.00								Recurring Annual Cost																																															
8	Purchase Additional Jerome Monitors	\$60,000.00	\$0.00	\$60,000.00																																																							
9	New Annual O&M Cost	\$0.00	\$2,000.00					\$2,000.00								Recurring Annual Cost																																											
10	Increase Bioxide Chemical Dosing	\$0.00	\$40,700.00					\$40,700.00								Recurring Annual Cost																																											
11	Washing of Treatment Process Tanks	\$0.00	\$36,000.00					\$36,000.00								Recurring Annual Cost																																											
12	Optimize Wet Scrubber Chemistry	\$0.00	\$80,500.00					\$80,500.00								Recurring Annual Cost																																											
13	Modify Wet Chemical Scrubbers Sumps	\$705,000.00	\$0.00																																																								
14	Scoping, Budget, RFP	\$25,000.00	\$0.00	\$25,000.00																																																							
15	Consultant Selection	\$10,000.00	\$0.00									\$10,0																																															
16	Design	\$200,000.00	\$0.00													\$200,000.00																																											
17	Const. Contract Procurement	\$10,000.00	\$0.00																	\$10,0																																							
18	Construction	\$460,000.00	\$0.00																					\$460,000.00																																			
19	New Annual O&M Cost	\$0.00	\$50,000.00																																																								
20	Increase Frequency of Fenceline Odor Monitoring	\$0.00	\$27,000.00																																																								
21	Secondary Sed. Tank Mixed Liq. Line Draining	\$50,000.00	\$50,000.00																																																								
22	Temporary Covering of Process Tanks	\$85,000.00	\$0.00																																																								
23	New Annual O&M Cost	\$0.00	\$15,000.00																																																								
24	Ventilation System Inspections	\$0.00	\$63,000.00																																																								
25	Purchase OdaLogs Monitors	\$32,000.00	\$0.00																																																								
26	Pre-Chlorination Rate Increase	\$0.00	\$110,000.00																																																								
27	Wastewater Liquid Sulfide Monitoring	\$0.00	\$45,000.00																																																								
28	Cover Mixed Liquor Channel	\$1,000,000.00	\$0.00																																																								
29	Scoping, Budget, RFP	\$75,000.00	\$0.00																																																								
30	Consultant Selection	\$10,000.00	\$0.00																																																								
31	Design	\$200,000.00	\$0.00																																																								
32	Const. Contract Procurement	\$30,000.00	\$0.00																																																								
33	Construction	\$685,000.00	\$0.00																																																								
34	New Annual O&M Cost	\$0.00	\$33,000.00																																																								
35	Clean Packed Tower Mist Eliminators Monthly	\$0.00	\$18,000.00																																																								

Cost estimates have been adjusted by an inflation factor of 3% to account for increases since the costs were estimated.